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OF THE
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Hygiene of the Boot and Shoe Industry in Massachusetts

STATE BOARD OF HEALTH

1912

FRANK L. KELLY, M. D.

STATE BOARD OF HEALTH.

HYGIENE

OF THE

BOOT AND SHOE INDUSTRY

IN MASSACHUSETTS.

AN ORIGINAL ARTICLE

PREPARED FOR THE STATE BOARD OF HEALTH BY THE

ASSISTANT TO THE SECRETARY OF THE BOARD,

WILLIAM C. HANSON, M.D.

INCLUDING A DESCRIPTION OF A PRACTICAL METHOD OF OBTAINING DUST RECORDS IN DUSTY OCCUPATIONS, AND ITS APPLICATION TO THE OPERATIVES' PROTECTION,

DEVISED BY

WILLIAM W. WALCOTT, M.D., NATICK,

State Inspector of Health.

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Hygiene of the Boot and Shoe Industry in Massachusetts.

To all the State Inspectors of Health is due the credit of examining the shoe factories in their respective health districts; to Drs. Simpson, Coon and Washburn that of making special investigations of the effects of dust generated in the course of manufacturing processes on the health of the workers; to Dr. Wm. W. Walcott that of devising a new, practical and scientific method of procedure in obtaining dust records to show the need of special devices for the protection of employees against dust, applicable not only to the boot and shoe industry, but to all dusty occupations in Massachusetts.

Second only to the textile[1] industry as a whole, but of greater importance than either of the chief divisions of the same (cotton and woolen manufacture) alone, stands the boot and shoe industry. According to the census of 1909, while the value of the textile production of Massachusetts was $386,800,000, including $186,462,000 for cotton goods and cotton small wares, and $141,967,000 for woolen and worsted goods (including felt goods and wool hats), that of the product for the boot and shoe factories (including cut stock and findings) was $236,343,000. As in the case of textiles, so with boots and shoes, Massachusetts leads all other States, — indeed, she manufactures nearly half the shoes produced in the whole country: Massachusetts, $236,343,000;[2] all other States combined, $276,455,000.

In this enormous industry many thousands of persons are employed in a large number of factories in many cities and towns in all parts of the State; in 3 cities it is the leading industry and also in a number of towns. In the course of this investigation 483 factories, or all concerning which the Board had any knowledge, were visited. The factories visited included many of small size, as well as the largest and most modern establishments in the State. In order that the public may have a glimpse of some of the rooms of a modern shoe factory where the health, safety and welfare of the people are most completely protected, several photographs of such an establishment are herewith presented.

[1] Includes cotton goods, cotton small wares, woolen goods, worsted goods, felt goods, wool hats, silk and silk goods, hosiery and knit goods, carpets and rugs (other than rag), and dyeing and finishing textiles.

[2] The value of shoes alone was $187,046,000; cut stock and findings, $49,297,000.

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The processes involved in the manufacture of boots and shoes are nume ous and exacting, and, in the making of the better grades of shoes, consta and unremitting attention to the details of the work is required. Some these processes are accompanied by conditions which, unless care be tak to prevent their full influence, may cause injury to the health of the oper tives.

The introduction of machinery into the industry of shoe making h advanced rapidly, and to-day there is no important operation on a sh which need be done by hand. In the making of the better grades of sho no less than 58 machines, and sometimes twice that number, are broug into play.

Many of these machines are common to the manufacture of all kinds shoes; others are used in connection with the production of certain grad only, for in the main the making of shoes is divided between the McKa the Goodyear and the Turn processes. The McKay and Goodyear pro esses differ in the manner in which the sole is stitched to the upper par of the shoe. The Turn process is that in which the shoe is made inside ou and is generally confined to the manufacture of light grades of women shoes and slippers.

For a proper understanding of the hygiene of the industry the followin description of the work of the various departments is presented.

To make a shoe there is required leather for the upper parts and sole cloth for the linings; thread to stitch the different parts together; nai for the heels and lasting; cement for adhering surfaces, and, in a shoe mad by the Goodyear process, cork for filling the space left between the inne and outer soles.

The manufacture of a welt shoe passes through about 106 different pai of hands, and is obliged to conform to the processes of a large number o machines. It would seem that in so vast a number of operations confusio would occur, and the different kinds and grades of shoes going through th factory would become hopelessly mixed. This, however, is not the case for when an order is received in the factory care is taken that each lot i given a distinctive number. This number, together with the details con cerning the preparation of the upper parts of the shoe, is written on tag and sent to the foreman of the cutting room. Similar tags concerning th sole parts are sent to the foreman of the sole leather room, while other go to the foreman of the room in which the shoes are to be made. By thi method the foreman of each room can prepare the stock necessary, and th shoe may be identified at any stage of the process in the factory.

The first process of making the shoe is begun in the cutting room. Here the "upper stock" and lining material for the shoe is laid out on benches,

examined carefully for imperfections, and cut into the required shapes and sizes by men and boys. This work necessarily requires a good light and is generally done on the upper floor of the factory where the light is the best. In some establishments, where large quantities of shoes of the same pattern are manufactured, hand labor in cutting is replaced by the use of the so-called "clicking" machine. This machine is a mechanically operated die, and, it is stated, does the work of more than 2 men.

When the different leather parts have been fashioned by the cutters some of the edges which show in the finished shoe must be "skived" or thinned down to a bevelled edge by a machine designed for the purpose. In raw-edged shoes the edges are blackened before they are skived. For the most part aniline dyes are used in this process. Occasionally, however, lamp black, thinned down with naphtha, is used and special precautions have to be taken to prevent the possibility of naphtha intoxication of the boys and young women who usually do this work. After being skived, the edges are given a coating of cement and folded over and pounded down by hand or by a machine, until the edge presents a smooth and finished appearance. The toe cap, in addition to being skived, is generally perforated along the edge with a series of ornamental perforations. The cloth linings for the shoes are cut out by men or boys, while the reinforcement of parts with cotton cloth is done by machines, generally attended by boys who may sit or stand at their work, as they wish.

The remnant pieces from the operation of cutting are saved for the small parts of the shoe, — tongues, eyelet stays, etc., — and are cut out by boys and young men with dies and mallets. Sock linings are cut from sheepskins by men who also stand at their work.

While the small parts for the shoe may be, and are frequently, made in the factory, it is now common practice to purchase these parts from the remnant dealers. These dealers purchase the remnants from the factories, and with their facilities can, as a rule, sell the small parts to a manufacturer as cheaply as he can make them up himself.

Before leaving the cutting room all the upper parts are stamped with case lot and order number for identification, and are then sent to the stitching room.

In the stitching room by far the greater number of those employed are women and girls who sit at their work. The process of stitching demands a room whose lighting conditions are good, and the stitching room is almost invariably so placed that good lighting conditions are obtainable. In the short days of the winter months artificial lighting is necessary. This light is, in by far the greater number of factories, furnished through the use of electricity, as gas, with its flickering flame, gives too uncertain illumination.

Before the parts of the shoe are put together the corresponding parts of the lining are joined and stitched by a stitching machine, trimmed, and then attached to the "outside" by means of other similar machines. Most of the machines used in these processes are operated by women who become expert in their use, though in some factories men also work at these machines.

In some instances, according to the process of manufacture, the edges of the vamps, or fore parts of the shoes, are covered with a cement made of rubber and naphtha. This cement was formerly kept in small bowls on the benches in front of the girls employed at this work, who naturally were exposed to the fumes of the naphtha arising therefrom. This cement is now kept in closed receptacles, the tops being opened for short intervals only when the operatives are actively at work, or, in specially constructed containers, so that the women and girl operatives are no longer exposed, to any extent, to naphtha fumes. The law relating to the exclusion of minors from occupations deemed to be injurious to health includes the use of naphtha in cement work in rooms in shoe and rubber factories which are not provided with mechanical means of ventilation, while the mixture containing naphtha is allowed to remain in uncovered receptacles.

The shoe is put together by stitching the vamp to the quarter. This is work that demands much care, and, while generally done by women, may be and is done by both men and women. Several processes are followed, according to the kind of shoe being made. Machines for eyelets and buttonholes are also run by women.

The process of stitching is one that is comparatively well paid, and employees are carefully selected for this kind of work. The stitching room is generally well kept, orderly and clean, and the hygiene of the room and the personnel of the employees is often a matter of pride with the forewoman in charge.

With the completion of the stitching process the preparation of upper parts of the shoe is finished. The different lots are properly tagged and marked and are sent to the making room to receive the sole leather parts of the shoe. These parts have been prepared in accordance with specifications and include the inner and outer soles, heels, counters and toe boxes. The soles have been cut by dies and rolled to a uniform size and thickness, and the inner soles, if for a welt shoe, have been channelled. The counters, toe boxes and heels are, as a rule, made outside of the factory by dealers who make a specialty of their manufacture.

The upper parts of the shoe and the inner sole are now fitted on the proper last and, by various mechanical processes, the upper is fitted smoothly to the last, all wrinkles and folds removed, and the outer sole is stitched on. In the welt process the shoe goes to a welt stitcher who stitches the welt

Exposure to odor of naphtha from open bowls of cement. No protection to workers.

Patent cans with covers to diminish odor of naphtha.

to the inner sole and upper; then the outer sole is stitched on. In these processes several complicated machines are employed, the description of which would be too technical for the present purpose.

When the outer sole has been stitched on there still remains the placing on of the heel, the trimming of the heel and sole to proper size and the finishing of these parts in black or other colors.

A full description of these processes is given below with an explanation of a new method of obtaining dust records for microscopical examination.

The completed shoe is sent to the packing process for touching up and subsequent shipment. Here any slight imperfection, crack or scratch in the shoe is remedied. Most of this work is done by women and girls who sit at little individual benches.

General Sanitary Conditions observed in Boot and Shoe Factories.

The construction, location and interior conditions of the shoe factories of Massachusetts vary so widely, even in the same community, that it is difficult to formulate general statements which would be applicable to all of them. Not a few of these factories are located in small country towns and are operated by employees descended from generations of shoe makers. These factories are generally isolated and, because of the absence of neighboring structures, quite well lighted. On the other hand, in the cities, where all available space is utilized, the buildings are at times crowded together, impairing the lighting conditions of the workrooms. It should be remembered, however, that, unlike the textile industry, the operatives in shoe factories work at machines or at benches placed along the sides of the rooms near the windows. The only exception to this may be found in the stitching rooms, where the operatives work in all parts of the room. This room, however, was as a rule found well lighted in all establishments visited.

It is to be noted that the modern buildings constructed for the shoe industry have been so placed that neighboring structures cannot shut out natural illumination. This feature of construction has proved a valuable asset to those who have constructed these buildings. Note has already been made of the use of electricity as an artificial illuminant.

The laws of Massachusetts require that all factories be kept clean and well ventilated, and these laws are well observed.

The odor of leather is inseparable from the art of making shoes, as is the odor of wool and of cotton in the textile industry.

One of the most vexing problems that has arisen in the inspection of shoe factories has been the maintenance of proper toilet facilities. This question, by no means common to the shoe industry, can only be met through repeated inspections and the education of the manufacturer. It is not

that the manufacturer is not willing or does not desire to maintain proper toilet facilities, but he is oftentimes careless and leaves this part of the work to others who fail in their duty. A decided improvement in these conditions has, however, been noted.

Conditions in 483 Factories, as to Light, Ventilation and Water-Closets.

Light: —	
Excellent,	30
Good,	441
Moderately bad,	2
Distinctly bad,	10
	483
Ventilation: —	
Excellent,	7
Good,	468
Moderately bad,	3
Distinctly bad,	5
	483
Water-Closets: —	
Excellent,	6
Good,	415
Moderately bad,	7
Distinctly bad,	55
	483

New Method of obtaining Dust Records in Dusty Occupations.

The following laboratory and field experiments were made possible under the health district legislation of the Massachusetts State Board of Health.

The importance of the subject may perhaps best be indicated by the following statement of complaint received from an executive board of a labor union, alleging that operatives in the shoe industry "suffer a great deal from the flying wax and dirt that profusely flies from the wheels and brushes of a certain kind of machine." The question arose at once as to the kind, size and amount of dust to which the operatives were exposed, not only by the process referred to, but by all processes in which dust was a factor.

Some of the processes in the manufacture of boots and shoes give rise to varying amounts of irritating dust. Among the processes that are of especial sanitary importance are trimming, shaving, scouring, polishing, finishing and cleaning parts of the shoe. The kinds of dust generated

L. KELLY, M. D.

On right, edge trimmer. "C." Shank cutter. Three shoes. Light moist stock. Hood and blower inefficient.

On left, edge trimmer. Light moist stock. Poor hood on fore part trimmer. No guard on shank cutter. Blower fairly efficient.

On right, edge trimmer. "C." Fore part trimmer. Three shoes. Light moist stock. Hood and blower inefficient.

On left, edge trimmer. Three shoes. Light moist stock. Hood and blower efficient.

Heel shaver. Three shoes. Light dry stock. Hood and blower inefficient.

FRANK L. KELLY, M. D.

On right, old style Naumkeag machine, A. Three shoes. Light moist stock. New coarse emery pad on wheel. Hood and blower inefficient.
On left, Naumkeag machine. Three shoes. Hood and blower unusually efficient.

On right, bottom finishing. Bench roll " A ". Twelve shoes. Mask worn by operative. Makeshift guard somewhat diminishing exposure to dust.

On left, bottom finishing. Bench roll " B ". Twelve shoes. Mask worn by operative. Unsuccessful makeshift guard to diminish exposure to dust.

Xpedite machine. Three shoes. No hood or blower.

include leather, fine lint, fiber, bristles, dried blacking, wax, sand, emery and carborundum.

A sheet of heavy white gummed paper, 10 by 7 inches, was fastened by clips to a piece of cardboard of the same size. The paper was covered evenly with a solution containing 30 per cent. glycerine and 70 per cent. water applied with a piece of absorbent cotton. The paper prepared in this way remained moist and sticky for about ten minutes. Dust records were taken in the following manner: —

An operative was observed buffing the sole of a shoe on a revolving roll composed of paper, cloth and carborundum which was giving rise to much fine dust such as would come from the process of sandpapering. The carborundum covered roll was making several thousand revolutions per minute. This meant that without an efficient dust removing device the workman's face was necessarily exposed to much of the rapidly flying fine dust. The exact or varying position of the workman's head was noted in relation to the machine and his manipulation of the sole of the shoe; as for example, the distance between his face and his work, and the plane — horizontal, perpendicular, etc., — in which he held the leather while at work. He was then asked to hold his head one side so that the gummed paper might be held in the positions usually occupied by his face, — that is, at the same distance from his work and in the same plane — while he buffed the soles of a number of shoes. The dust to which the workman's face was formerly exposed now became adherent to the gummed paper and its amount and character noted. At once, before the glycerine-coated paper dried, it was covered with a sheet of very thin, transparent "bond" or "rice" paper ruled in inch squares, and a permanent record made for macroscopical or microscopical study. The record was noted and labelled with the necessary data such as the name of factory, town or city, date, nature of process, number of shoes worked upon, condition of stock, — whether coarse, light, dry or moist, — as well as special notes in regard to shape, construction, adjustment or condition of hood, and the condition and efficiency of the dust-removal system.

In processes where the workman moved his head about a good deal, as when using the "shank roll" and xpedite machine, a mask was prepared for him to wear, owing to the difficulty of the examiner in following the exact position of the workman without directly interfering with the work. The mask was simply constructed by cutting eye holes in the cardboard and gummed paper, which was held firmly in place by clips on the head band of a head mirror.

In conducting such experiments there were certain errors that must be considered, in addition to examining the entire dust-removal system. It might be thought, for example, that the wearing of a mask by a workman under examination would result in a more accurate dust record than the holding of a record paper by the examiner in the position of the workman's face. On the contrary, any error in position that the examiner might

make while taking the records could be considered practically a "constant", while with the mask, which was over and in front of the workman's face, — hence a little nearer the work, — more dust would be collected. Moreover, it was found that any error in the position of the mask record paper varied for each employee. Then, too, whenever the mask was to be used, the examiner first watched carefully the workman at his work before it was put on, to note the distance between his face and his work, and again, after the mask was adjusted, to see that the workman did not hold his face nearer his work than usual. A tendency was noted among the operatives to provide as much dust as possible for a record; for this reason several sources of error that might be introduced by operatives had to be guarded against. Other sources of error were considered in connection with the taking of records, among them being undue length of exposure of the records because of the more or less constant stirring up of dust on belts and shafting, improper adjustment of hoods, clogging of pipes, leaking pipes, bad connections, poor draft, small openings, small pipes and changes in work on the same machine.

In order to obtain records of light-colored or white dust, such as white wax and lint from cotton buff balls, a black gummed paper was used and the record covered as usual. As the transparent paper was necessarily white the white dust, if very small in amount, was difficult to see when covered. To obviate this difficulty this record was covered with sheet gelatine which was perfectly transparent. While this method was not used as a routine procedure on account of the expense, one record in a series was so mounted and the other records covered in the usual manner. As a rule, the dust caused in the process of handling the part in question on three shoes constitutes a record, except in the case of very fine dust, when "12 shoe" records were taken to permit easier and more accurate comparisons.

The method of obtaining a dust record for microscopic examination is as follows: —

An ordinary glass microscopic slide is covered with a very thin coat of silicate of soda or mucilage of acacia by means of a fine camel's hair brush. The slide is then placed in the clamp shown in the cut which the operative holds in his teeth for a given time while he continues his work. The slide is removed and quickly placed in a covered slide box to prevent contamination by dust from belts or pulleys. It is better not to use a glass cover, as its use gives rise to air bubbles, especially in dealing with the coarser dusts. The bottle of acacia or soda must be tightly corked and the brush thoroughly cleaned or a new one frequently provided. Microscopic examination of the dust in each case was made.

When a record, or series of records, showed that an operative was ex-

posed to an undue amount of dust, the next fact determined was whether the hood or exhaust system or both, was at fault, or whether the nature of the process made it necessary that the operative be exposed to considerable dust. In general, it may be stated that a hood to be efficient should cover the dust-producing machine as completely as possible without interfering with the work of the operative. To determine this fact it was necessary to consider separately each process and each machine in addition to the idiosyncrasies of the various operatives. For example, a record taken with the view of determining whether an occupational process is sufficiently injurious to the health of minors to justify their exclusion therefrom might show that the exposure of the minors to dust causing any injury to the minor is due, not to the occupation itself, but to an ineffective method of dust removal.

In addition to factors already mentioned that influence the amount of dust produced, three were of great importance, viz.: (1) the diameter of the dust-producing unit; (2) the speed at which it was driven; and (3) the direction in which it revolved. With reference to the speed of the dust-producing unit, it is evident that a large knife or brush revolving rapidly will throw more dust a greater distance than a small one revolving slowly. For this reason many speed records were taken upon the various machines to determine the number of revolutions per minute. For purposes of comparison the dust-producing records of different diameters and speeds had to be reduced to a common factor; that is, they had to be considered in terms of "peripheral speed." This was done by the formula $\pi D N$, that is, 3.1416 $\times$ the diameter of the wheel in inches, $\times$ the number of revolutions per minute, divided by 12, to reduce it to feet per minute.

The variations in speed found in the same process led to conferences on the subject with manufacturers, superintendents and foremen. In the process of edge trimming, for example, tests in one factory showed that the knives were running between 7,000 and 8,000 revolutions per minute, while in another establishment between 10,000 and 11,000.

Another difficulty to be reckoned with was the fact that the shafting connected with machines making 11,000 revolutions per minute was observed to be "pounding," a happening which not only caused the machine to throw more dust, but to be a less smooth grade of work, and at the expense of more power, oil and repairs. In the process of bottom finishing, where a bristle or large wheel was run at 800 revolutions per minute, instead of 1,200 or 1,300, the blacking was "dragged" comparatively slowly over the surface, thus not only giving a better finish, but causing less dust; that is, such dust as dried blacking, fiber and bristles. The slow-speed brushes were not popular with the operatives, however, owing to the fact that the work was piece work, and that more shoes could be finished in a given

time upon a high-speed brush. In case of low-grade work, where the finish was not of first importance, it was found that the high-speed brushes materially increased the output of the factory. Considering, therefore, the many grades of work, it was evident that the speed of machines was a separate problem for each factory and must be considered as such.

The process known as "edge trimming" gives rise to much coarse and to considerable fine dust. The machine for trimming the edges of the sole of the shoe contains a circular knife composed of a number of cutters. Knives of different shapes are used for different edges. The number of revolutions which the knife makes per minute varies from 7,200 to 11,000. The workman who sits at his work after shaving or trimming to a given width the sole and shank of one shoe must trim the edge of its mate to a corresponding width. This requires good light, accurate eyesight, considerable skill and close attention. The fore part or sole trimming is done by holding the sole against a circular knife 1½ inches in diameter, with several cutting edges, making about 9,000 revolutions per minute. The shank cutting is done by a similar but smaller knife, 1 inch in diameter, revolving at about the same speed. The operatives sit for the most part at their work in a strained, humped over attitude, due, chiefly, to the fact that the seats are generally unsuited for the work. The seats consist of stools of various sizes and boxes turned on end with or without makeshifts for backs and cushions. The machines, as a rule, are placed before windows. In many instances electric lamps are directly over the machine, so that the light is thrown upon the work and not into the eyes of the operative. Considerable fine dust arises from the process. The dust is thrown off at a tangent, and, for the most part, lands upon the operative's right arm and shoulder, although much flies into the operative's face. The amount of dust going to the face depends largely upon the workman's posture, which, in turn, depends upon his eyesight, as a nearsighted operative necessarily holds his face nearer the machine; it depends also upon such other conditions as drafts from windows, belts and pulleys, and the grade of efficiency of the hood and blower system. The fore part trimmer throws most of the fine, and the shank cutter the coarse, dust. The amount of dust generated by the machine depends largely upon the condition and character of the stock, — fine and wet stock causing the least, and coarse dry stock the most. Another important factor to be considered is the manner in which the operative works. For example, some employees keep a pan of water and brush on the bench, and moisten the edges of the soles before trimming them, thus reducing materially the amount of dust. Many employees, however, do not do this, while some do it part of the time. On questioning a number of operatives and foremen it was found that the same type of work might be turned out with or without moistening the edges. After

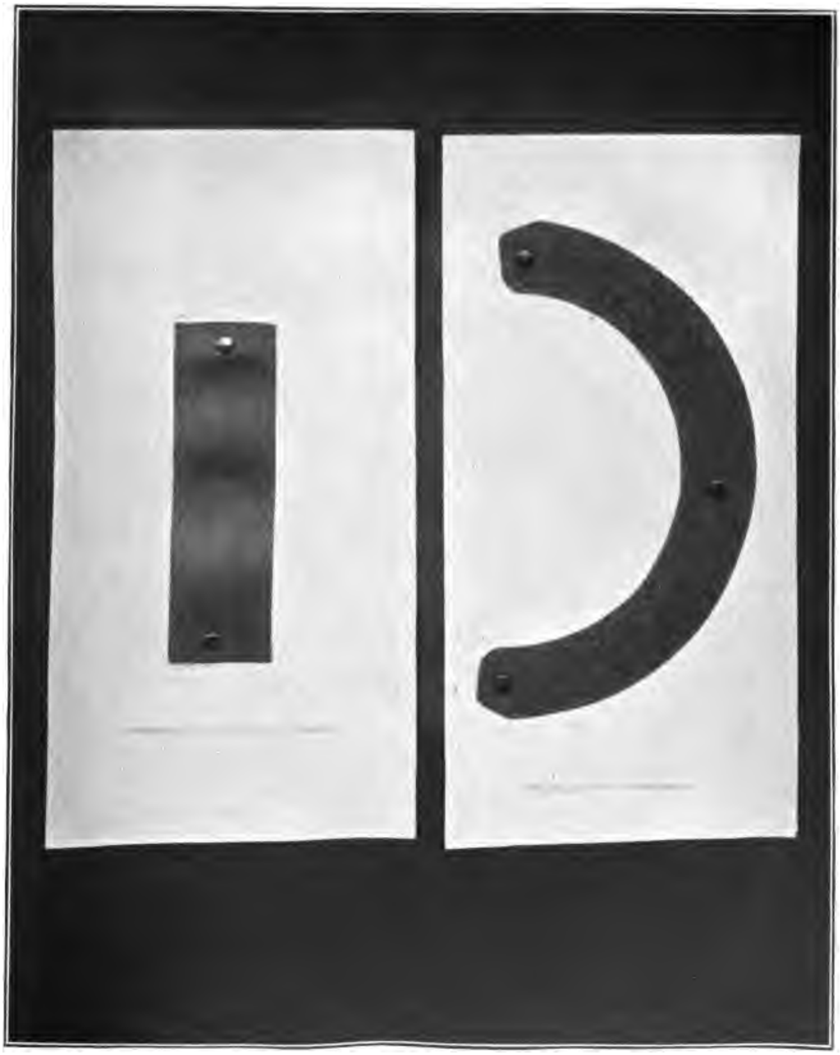
Edge trimming. Cloggy pipes; dust-removal system not satisfactory.

Edge trimming. Effective dust-removal system.

Edge trimming. Effective dust-removal system.

FRANK L. KELLY, M. D.

Heel scouring. Ineffective exhaust draft for removing dust.



**On right, sand paper used on " breast scourer."
On left, carborundum paper used for heel scouring.**

careful investigation of existing conditions, the conclusion was reached that with an efficient hood and exhaust system practically all the dust could be removed.

For various reasons, which will be discussed later, machines were frequently found to be inefficiently equipped with dust-removing devices. Operatives commonly attached paper, pasteboard, tin, wooden or felt guards to various parts of hood or machine. Some of the devices were both ingenious and effective. On the other hand, it was observed that by attempting to improve upon an already efficient hood by bending it, or by trying to change the direction of the draft by stuffing rags in certain positions of the pipes, the entire system was made inefficient. This appeared to be the chief reason why a hood, instead of being adjustable, should be of such material that it cannot be easily bent, cut or bored.

In the process known as "heel shaving" the rough edges of the various pieces of which the heel is built up are cut away leaving it with a fairly even surface, and reduced to standard size and required shape. The workman must exercise great care to do the work properly, and avoid injury to his fingers. He stands in front of the machine which is about 4 feet high, and, in order to see every portion of the heel, he must bend his head and shoulders forward. Because of the swiftly revolving knives, he grips the shoe tightly with his left hand over the heel and his right over the toe. The work causes circular or oval shaped callosities of varying thickness on the outer and upper aspect of the last two joints of the left forefinger, and commonly, also, of the middle finger of the left hand. The constant standing is favorable to the development of the condition known as flat foot which is not uncommon among these workers. The machine has a pipe and exhaust draft system, as in the case of edge trimming, designed to draw the dust away from the workman's face which is commonly brought within 7 or 8 inches of the knives. The machines are situated in front of the windows, and artificial light is seldom provided, as the work is not particularly exacting and does not involve the eye strain found in edge trimming. The knives are coarser than those used in edge trimming, about 3 inches in diameter, and make from 5,000 to 6,600 revolutions per minute. Owing to the nature of the work in the use of coarse knives, large chips and considerable coarse dust are produced. Most of the dust and chips are thrown horizontally or downward; comparatively little reaches the operative's face. The machine is a particularly difficult one to equip properly with an adequate hood and exhaust. For example, with the heel as a center, the operative must rotate each shoe through an arc of considerably over 210 degrees.

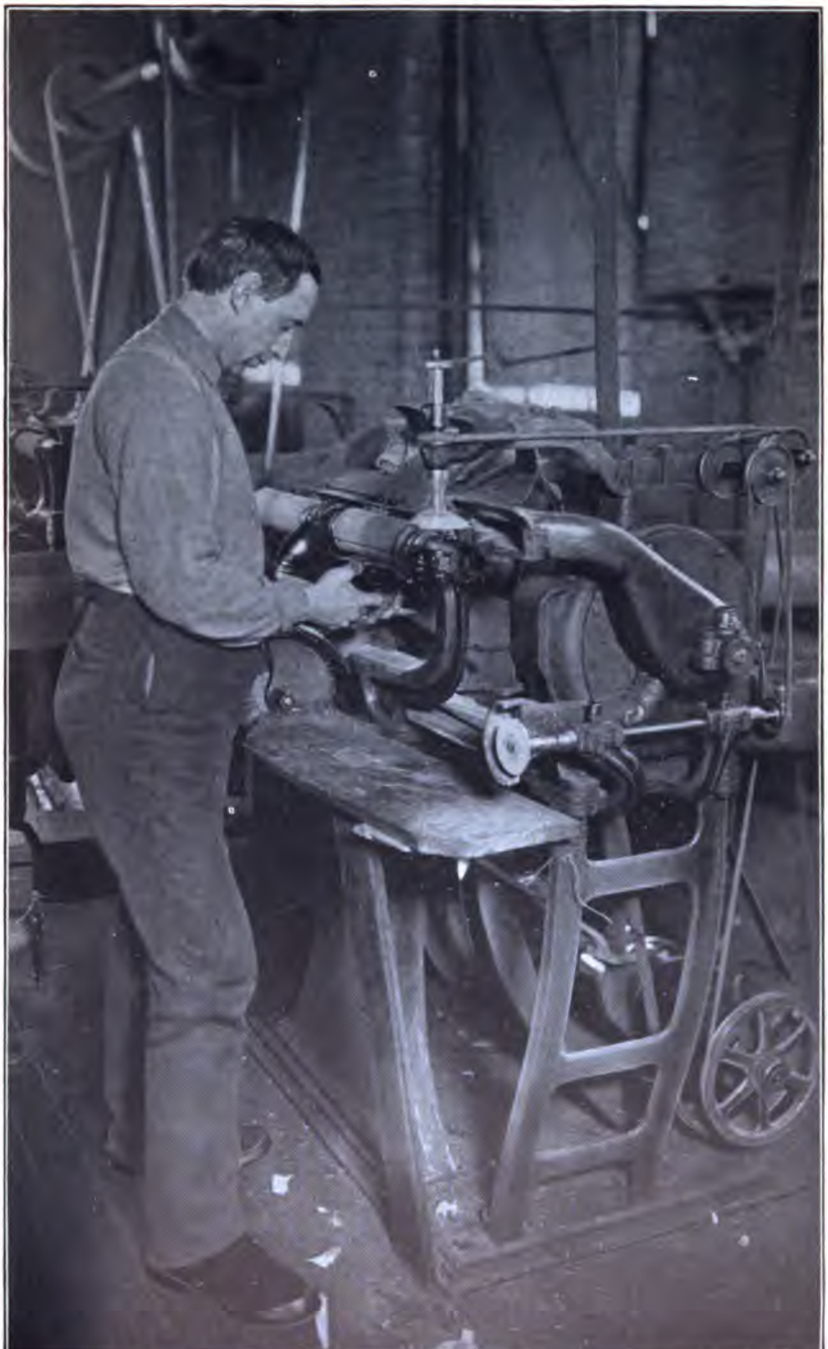
In "heel scouring" a felt wheel is used "faced" with carborundum or sand, molded paper and cloth. The wheel is 6 inches in diameter, with a

2-inch "face." It revolves in a vertical plane from 4,000 to 5,500 times per minute. The machines are usually in front of windows and seldom require artificial light. The operative stands at his work with his face above it and in 45 degrees plane. Only a moderate amount of fine dust, sand, carborundum and leather is generated, and most of this is carried down inside the machine by a suction draft. The machine is easily equipped with devices for protecting the employees against dust. Breast scouring gives a smooth finish to the front part of the heel or "breast." It is done on a machine with a 3½ inch truncated wooden cone covered with a sandpaper or carborundum ribbon. Considerable dust is thrown off, although the work is neither hard nor exacting. On account of the small diameter of the cone, and the fact that the dust goes off at a tangent or downward, and as the machine is readily equipped with efficient exhaust blowers, little dust reaches the face of the operative. The machines are sometimes placed on benches before windows where operatives may, if they choose, sit. As a rule, the operatives stand at their work.

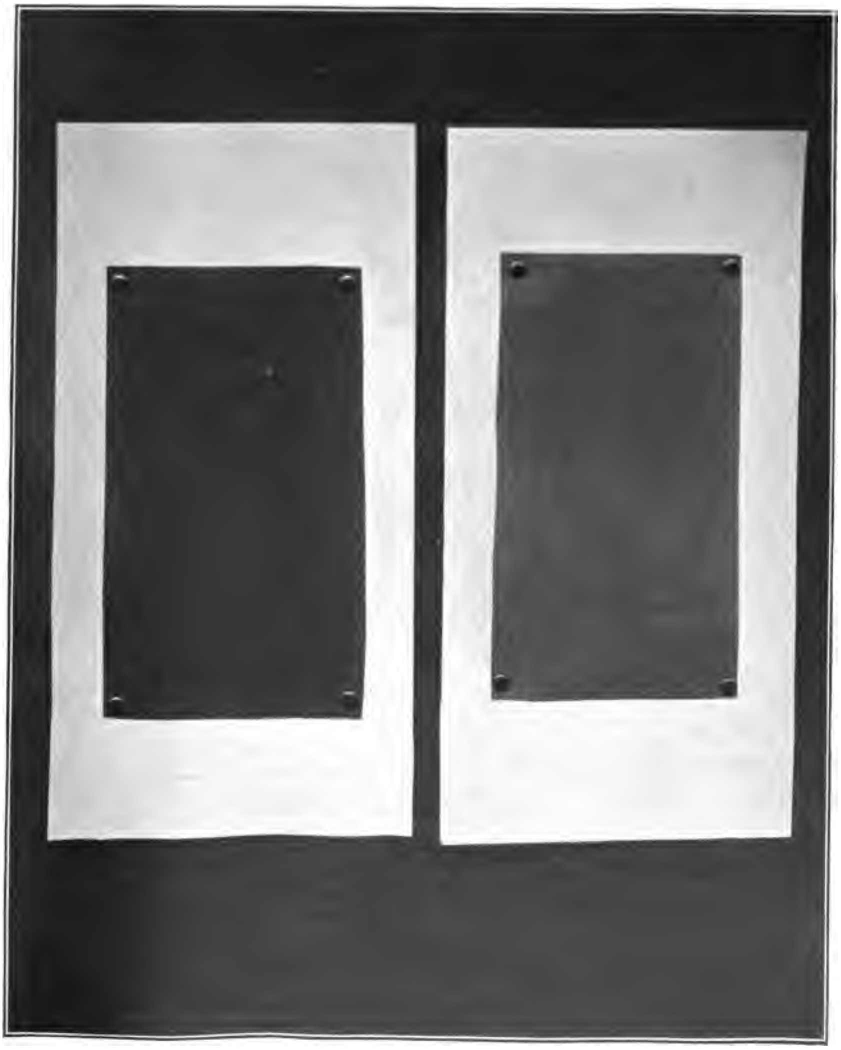
Bottom Scouring. — In this process the bottom of the sole and face of the heel receive a smooth finish. The work is done by a machine with a wooden roll 3 feet long and 4 inches in diameter, covered with sandpaper or carborundum. The roll revolves in a vertical plane making from 1,800 to 2,700 revolutions per minute. The operative standing at the machine draws the sole and face of the heel across the revolving roll. The operative is exposed to but little dust, owing to the fact that the diameter of the roll is small, and the dust generated is thrown downward or at a tangent. While the machines are near windows, as a rule, ordinary light is sufficient, and no eye strain is involved, as the work is not exacting and requires little skill.

Naumkeaging or Naumkeag Buffing. — The Naumkeag machine reaches that part of the shank which the rotary roll of the buffing machine cannot touch, and it scours, brushes and smooths the leather with carborundum for the staining process in the finishing department. It is really a part of bottom finishing. The work is done on a separate machine by a soft circular pad 3 inches in diameter, covered with emery paper. This pad revolves on a horizontal plane about 4,000 times per minute. Little skill is required to operate the machines, which are not necessarily placed near windows. The dust-producing unit is oftentimes within 8 or 9 inches of the operative's face. If a man is of medium height, or below the average, or nearsighted, he is much exposed to fine carborundum and leather dust. On account of improperly constructed hoods there is undue exposure to dust from this type of machine.

In addition to the dust-producing machines which deal with the processes concerned in the actual manufacture of a shoe, machines are em-

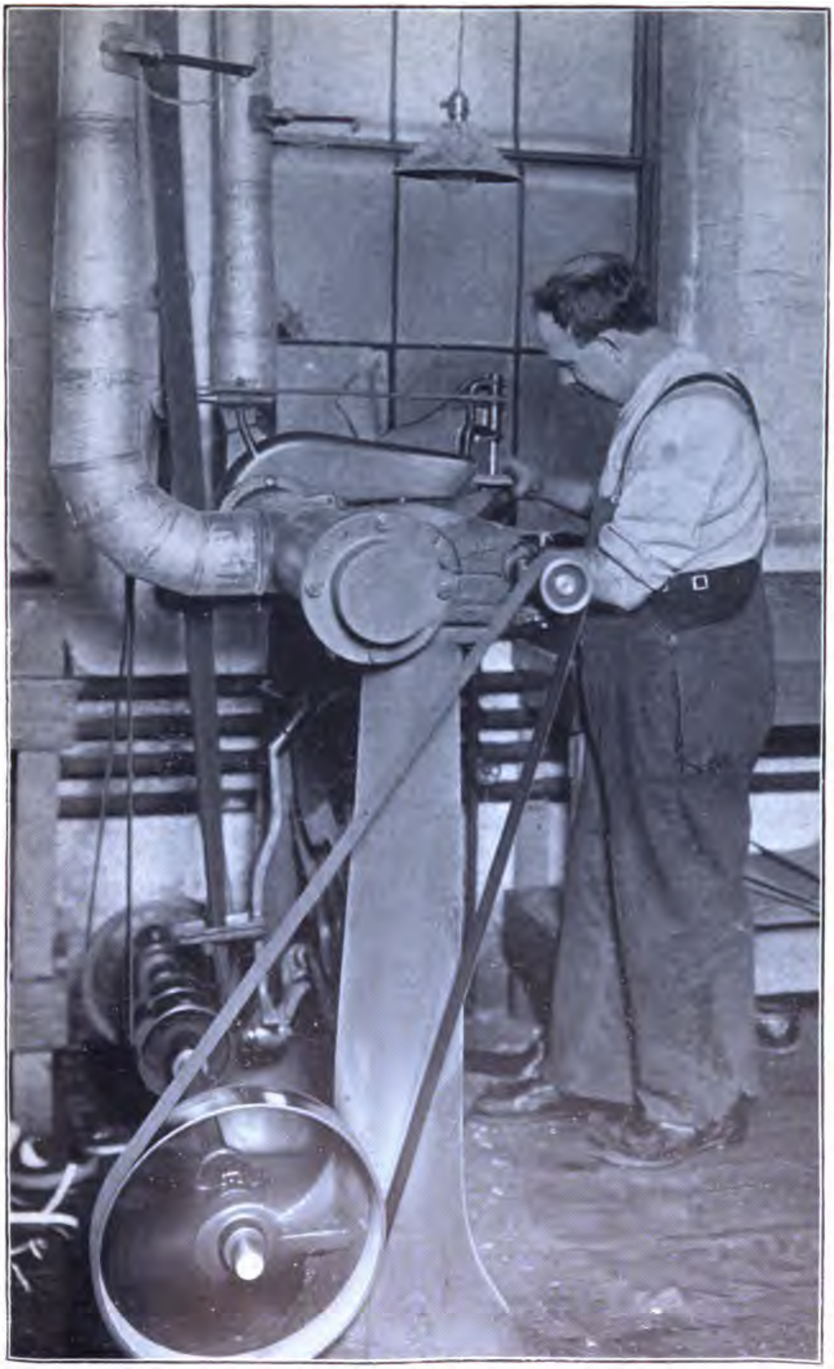


Bottom scouring. Ineffective removal of dust.



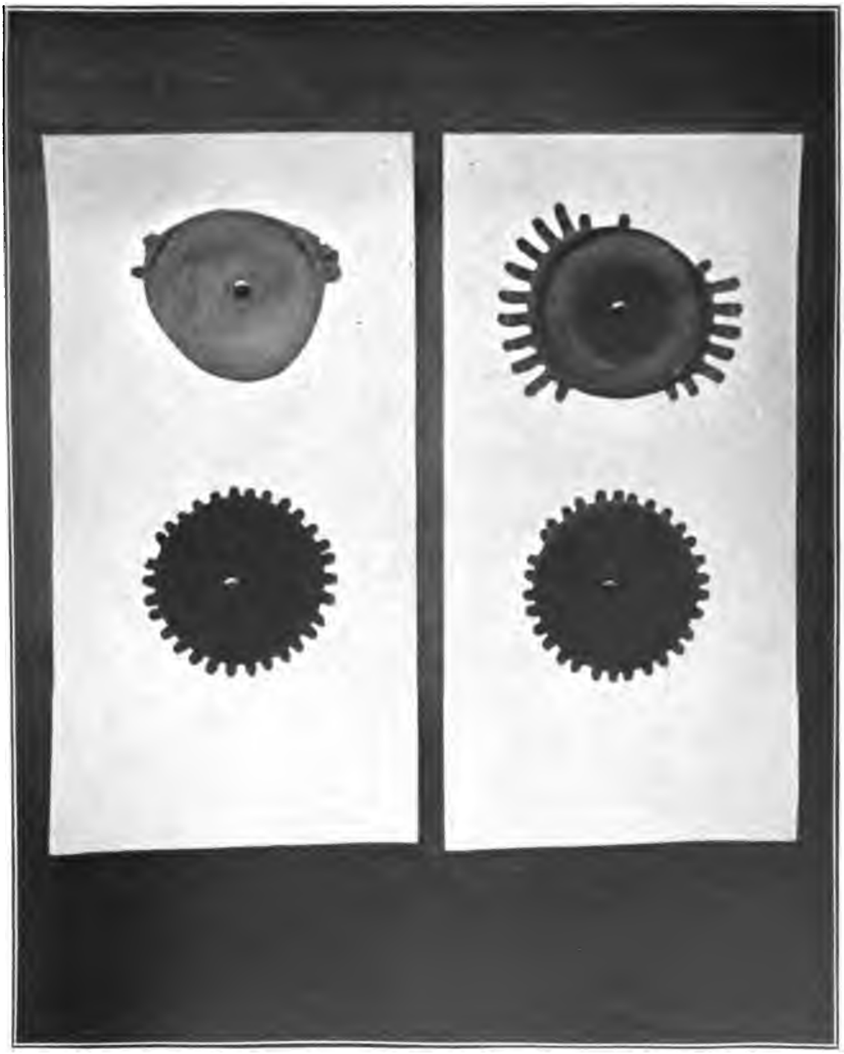
Coarse and fine carborundum paper used for bottom scouring.

Naumkeaging. Ineffective exhaust blower system.

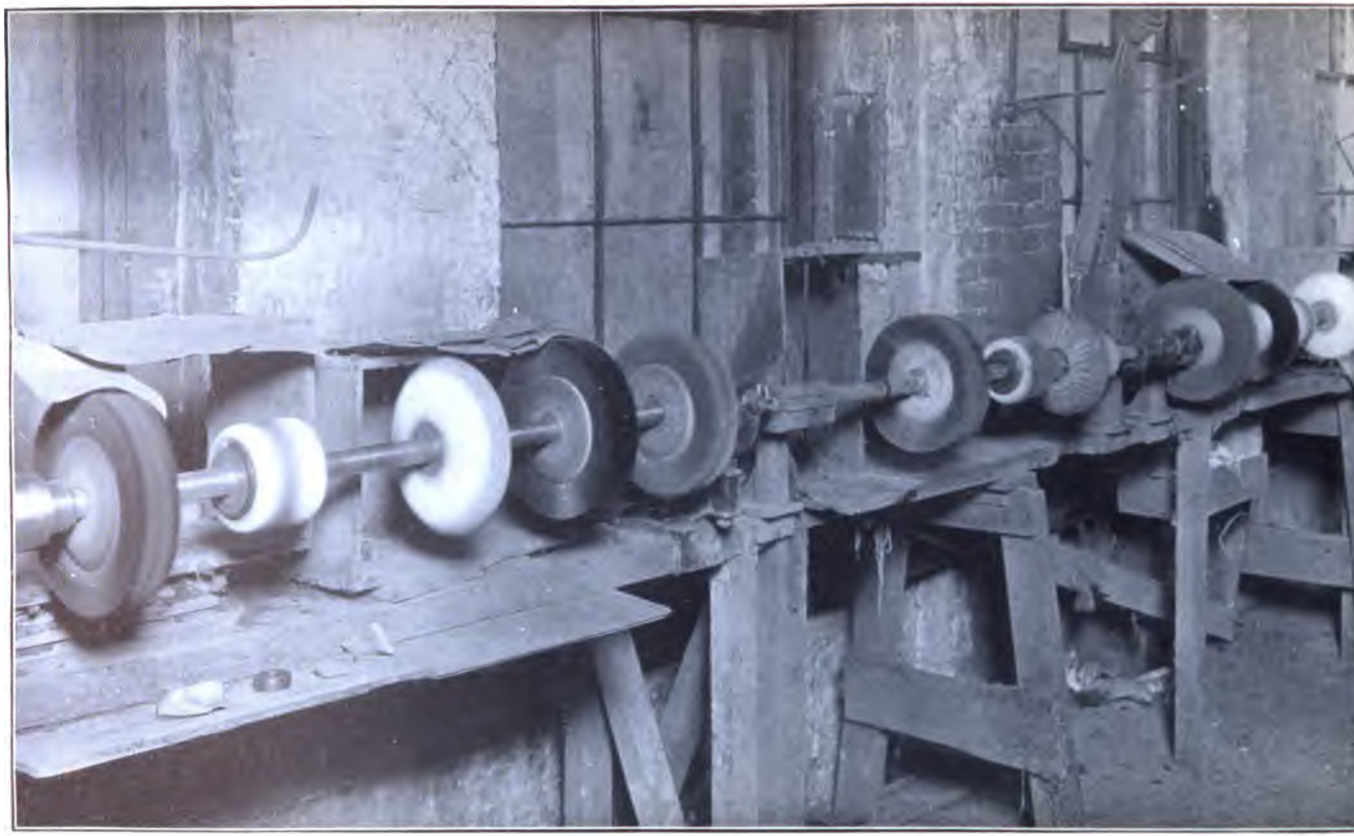


Naumkeaging. Excellent hoods and strong exhaust draft for removing dust.

FRANK L. KELLY, M. D.



On right, old and new pad of coarse carborundum used on the Naumkeag machine.
On left, old and new pad of fine carborundum used on Naumkeag machine.



Polishing shoes (bottom finishing). No dust-removal device.

Bottom finishing. Makeshift devices for protecting operatives against dust.

Bottom finishing. Effective dust-removal system.

ployed in the finishing processes which give rise to considerable dust. This dust is produced by the action of bristle and rag brushes on polishing preparations which have been applied to the sole and heel of the shoe. It is finer in character than leather dust, and may be black and sticky from the stains and wax used in the polishing preparations. In general, the amount of dust produced by any finishing machine is dependent upon the work at hand. A light Turn slipper with an uncolored sole and a wooden heel gives rise to but little dust in the finishing process, whereas a man's shoe with heavily stained sole and heel causes considerable dust. The actual finishing of a shoe consists of three processes, — heel finishing, bottom finishing, upper cleaning. These processes vary somewhat with different kinds of work, but in general may be described as follows: —

Bottom Finishing (Rolling, Bottom Rolling, Shank Brushing). — The manner in which the bottom-finishing machine is used depends, in a measure, upon the employee in charge of the department. Ordinarily, the machine consists of an arbor mounted directly on a bench. On this arbor are one, two, or more large bristle or canvas-covered brushes. The machine is designed to give a polish after previously blacking or coloring the shank, sole and breast of the heel. The employee in operating a machine holds a stick of polishing wax against the canvas-covered wheel, and by then pressing the bottom parts of the shoe against the wheel covers them with the polishing preparation. Pressure against the rag and bristle wheels completes the process. The polishing brushes used on this machine average about 12 inches in diameter, and the arbors run from 800 to 1,500 revolutions per minute. The dust thrown off from this machine consists of particles from the large brush, minute bits of broken hairs from the bristle brush and particles of wax and stain from the polishing and staining preparations. The amount of dust produced is considerable, and the machine is probably the dirtiest in the shoe industry. Practically few of these finishing or polishing machines are connected with blower systems or are efficiently hooded. Another dirty machine of this type is the "upper cleaner." It is not used in all shoe factories, but where it is used it generates a vast amount of dust, lint, wax and blacking as the upper part of the shoe is held against it. The machine is simply a large 10 to 15 inch rag or bristle wheel revolving about 1,000 times per minute. It is practically never provided with a blower system, and seldom with an efficient hood.

The xpedite finishing machine polishes the outer surfaces of the heels after they have been blackened. This machine consists of an iron frame, upon which are mounted two arbors. One arbor is 6 inches in front of, and slightly below, the other. The arbor in the rear supports at its left end a flat, slotted wheel, slightly less in width than an average heel. This heel wheel runs just near enough to a small wax pot, heated by a small gas flame, so

that it is kept evenly coated with a thin layer of wax applied by a series of rubbing blows. The heel is then presented to a rapidly revolving, small, flat brush which travels to and fro across its surface, causing a smooth finish of unusual brilliancy. The forward arbor supports two 7-inch bristle brushes, revolving at 750 to 850 times a minute, one of which is covered with a canvas jacket and has at its extreme left a small milled disc to mill the outer surface of the heel where it joins the shoe.

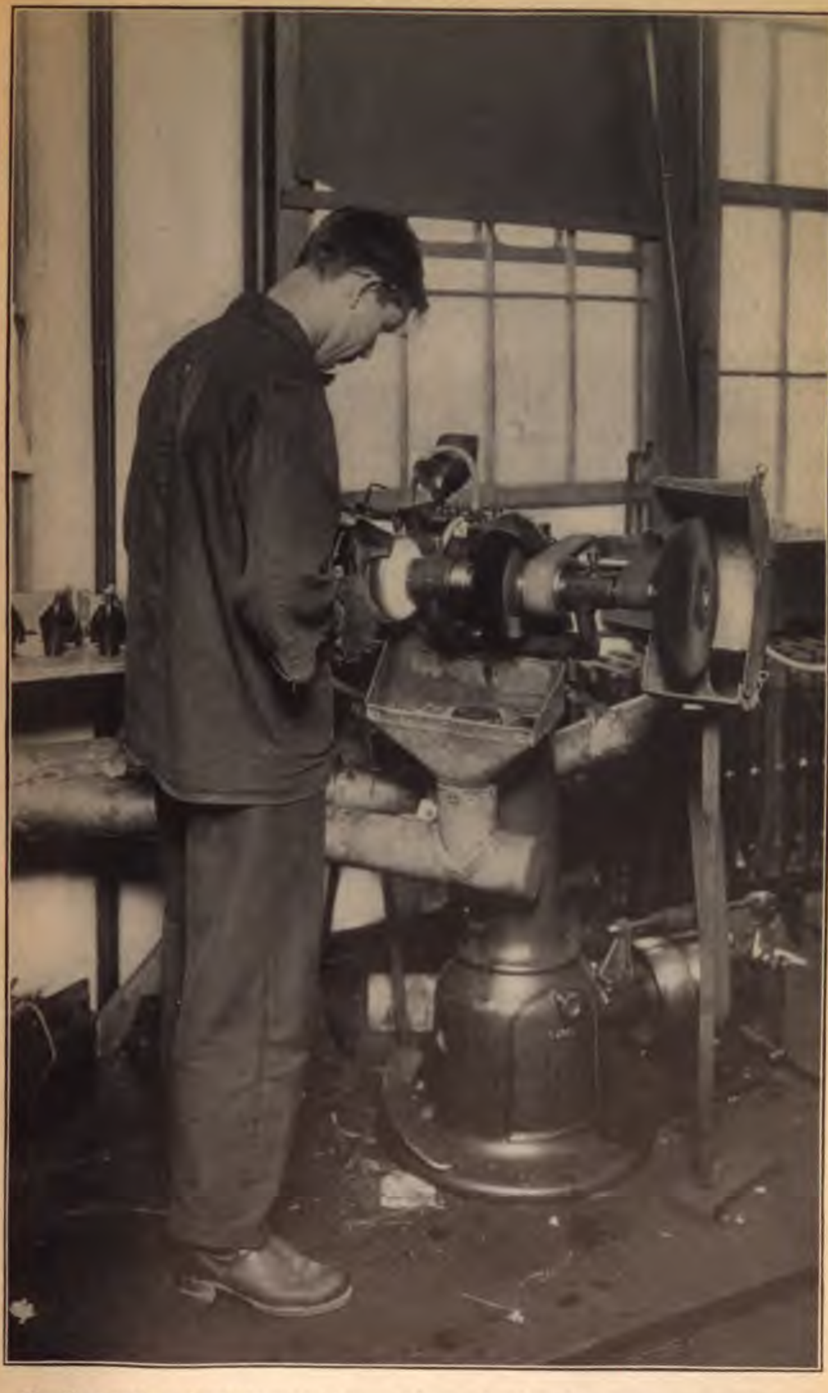
The operative, standing before the xpedite finishing machine, presses the heel of the shoe against the wax wheel. In this way the heel is covered with a thin layer of wax. By next holding the shoe against the canvas-covered brush, the wax is evenly distributed over the heel and hardened. In some cases the wax wheel does not provide enough wax. The operative then holds a stick of wax against the canvas roll and repeats the process. The heel finishing is then completed by brushing on the bristle wheel. Some machines are provided with an additional rag wheel for final polishing.

When improperly hooded the machine gives rise to considerable fine dust, consisting of a small amount of lint from the canvas roll, but mostly of fine particles of blacking, wax and bristles from the brush.

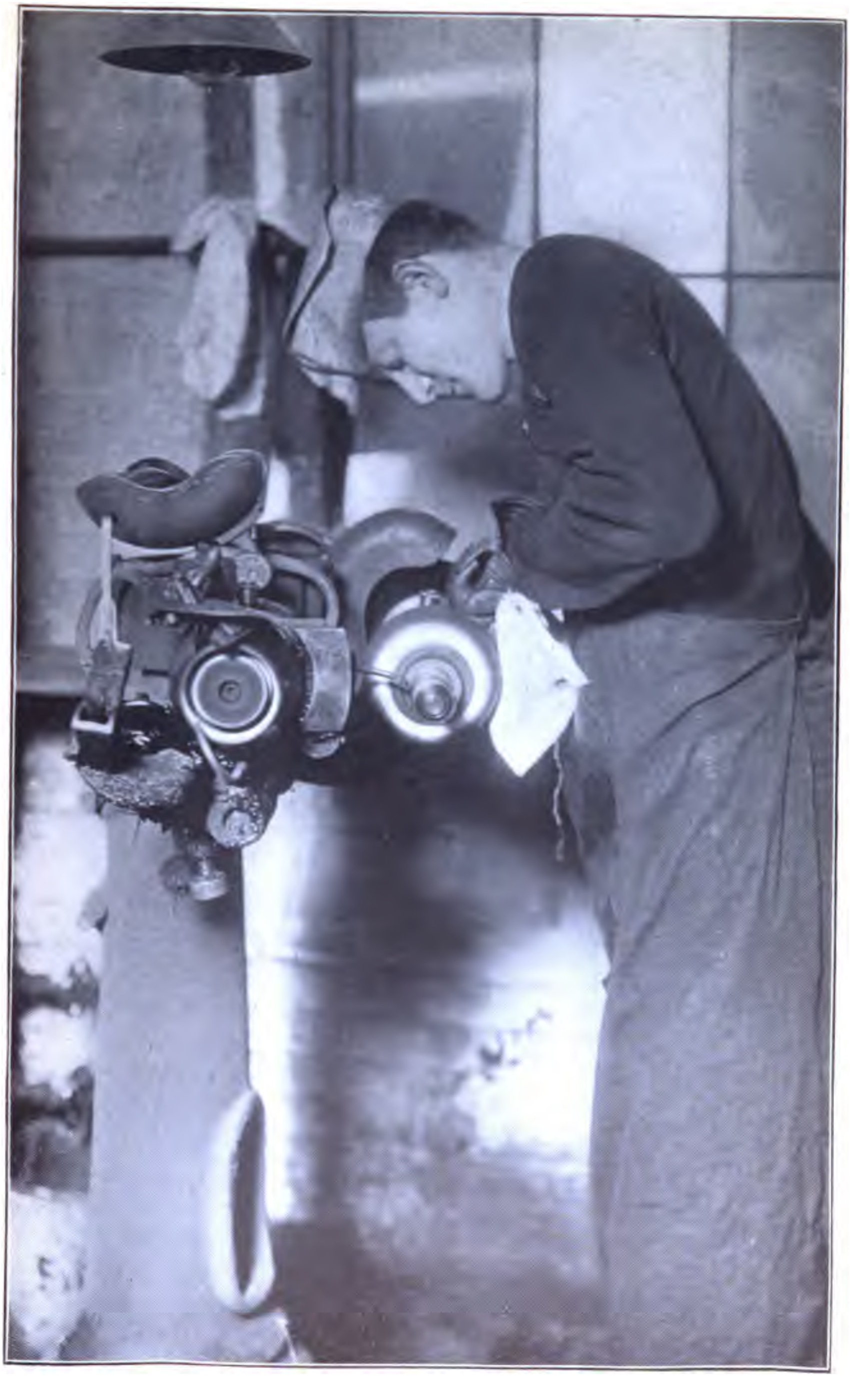
On account of the operative's posture, and the manner in which he does his work, comparatively little dust reaches his face. If a man is of average height, the dust-producing units are on a level with his waist line. The workman, bracing himself with his feet, uses his body to give additional pressure against the brush. This position brings his face in a horizontal plane above and slightly to the rear of the dust-producing units, so that most of the dust that escapes goes to the forearms, lower chest and waist. A short man is necessarily much more exposed to dust than a tall one.

The faces of the operatives are often dirty, but observation disclosed the fact that this was due more to the workman's touching his face with his soiled hands or handkerchief, or wiping the face on the forearms and sleeves, than to the dust deposited on the face from the brushes, provided the latter were properly hooded. On the other hand, investigation showed that operatives frequently tipped back the hoods of the machine and used them to hold their wax sticks, or removed the hoods altogether. In such instances, as well as in those instances where the machine was found improperly hooded, the workmen were covered with black, sticky dust.

Having noted the amount and nature of the dust, including the direction in which it was thrown, as well as other factors, such as posture, height of operative, condition of sight, etc., an attempt was made to determine why some machines were adequately hooded and others were inadequately hooded, with the view of devising, if possible, a remedy for the inadequately hooded machines. With the edge trimmer, for example, in the case of the forepart trimmer, much dust escaped in some cases because the edge of the



Xpedite machine. Hooded; one-half area of bottom hood used by workman for holding wax and other materials.



Xpedite machine. One hood out of position; used by workman for holding wax.

hood did not extend far enough over the knife. This fact was frequently recognized by the operative who had made additions to the hood, such as a piece of pasteboard, tin or wood. Records taken with and without these additions showed that the workman often made an inefficient hood entirely satisfactory. Conditions noted on the shank cutter were even more striking, as this machine was frequently found unguarded. By the simple device of placing a tin or wooden guard over the machine, much dust was kept from the operative's face. The reason why so many of the shank cutters were found unguarded was because of work done upon high heels. If the machine were guarded, the high heel would strike the guard when the shoe was turned and interfere with the work. Among the most satisfactory hoods for edge trimmers, one was found which came well over the knife of the forepart trimmer, and had an unusually high arch or dome. The dust was thrown against this dome and was caught by the draft as it dropped. The guard for the shank cutter was efficient and did not interfere with the work on high heels.

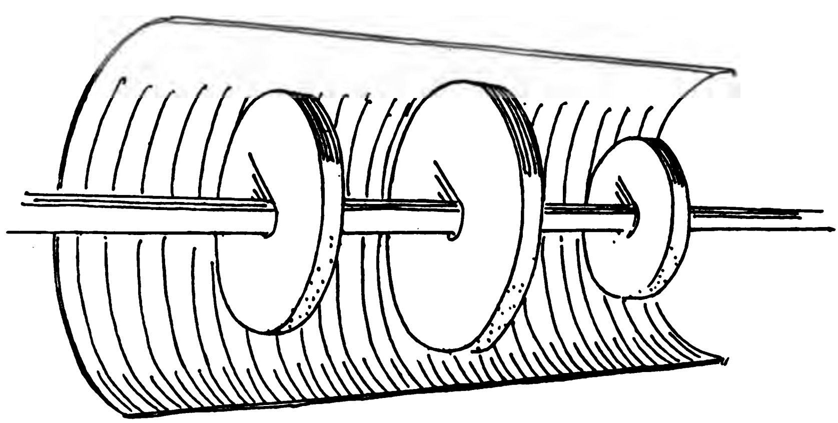
The hoods of the heel shavers and heel sight trimmers were found in practically every case to be satisfactory, owing, however, more to the nature of the machine and process than to the hood or exhaust system. As was previously stated, with the heel as a center, the operative must rotate the shoe through an arc of over 210 degrees, so that an efficient hood would seriously interfere with the work. Inasmuch as little fine dust is created, however, most of which is thrown down, the process does not appear to be particularly dangerous.

In the work of heel, breast and bottom scouring it was noted that little dust reached the operative's face because of the following conditions: the operative in conducting these processes usually stands at his work, and the dust-producing unit is low, near his waistline, in contrast to the edge trimmers. The dust-producing units are of small diameter, run at moderate speed, and throw most of the dust down or at a tangent, and not in the operative's face. The machines were, as a rule, well hooded. They could be efficiently equipped without interfering with the work. In the process of bottom scouring, one operative, it was found, had invented an effective device to prevent the dust from being carried around upon the sand roll. It consisted of a long brush with ½-inch bristles, attached to the rear of the machine and so adjusted that the bristles just cleared the posterior superior surface of the sand roll. It could be adjusted from time to time as the bristles became worn. The machine was thus practically dustless because it took care of the dust carried around upon the roll by centrifugal force.

Operatives using the Naumkeag machine were exposed to considerable fine sand and carborundum dust. In the first place, the dust-producing unit is so much above the level of the floor that the operative, if of medium

height, has his face within 8 or 9 inches of his work; a short man still nearer. The emery-covered pad revolving in a horizontal plane throws a cloud of fine dust in the operative's face. While doing his work the shoes with the heel as a center must be rotated through an arc of about 180 degrees, which obviously interferes with a hood so constructed as to remove all dust. While some exposure to dust is unavoidable in this process, conditions in many cases could be decidedly improved by rearrangement of exhaust pipes so as to give greater efficiency, adjustment of hood, and construction of some more efficient pipe, which is possible without interfering with the work.

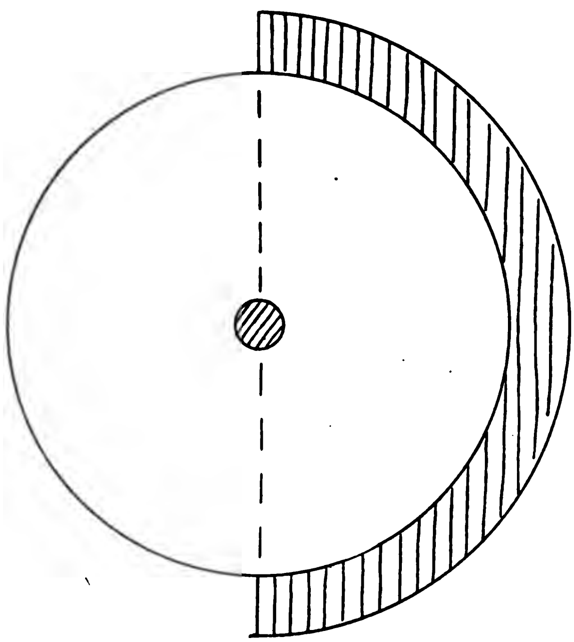
No department of the shoe industry requires more attention and receives less, as regards dust-removal devices, than that of bottom finishing. It is the dirtiest part of the work, and the dust is of such character as to be readily inhaled by the operative. The dust consists of fine lint, fiber, bristles, particles of blacking, stain and wax. It is very light and easily distributed; drafts from windows, belts, shafting, etc., keep it in suspension in the air. It will thus be understood that if machines are improperly equipped with dust-removing devices, the workmen will be covered with dust from head to foot. Notwithstanding this fact, it is not uncommon to find brushes or rag wheels entirely unguarded. The operative often placed a box behind the revolving brushes or used various makeshifts to



Sketch A.

protect himself as much as possible. It was the exception rather than the rule to find the hoods connected with the blower system. The hoods, in turn, were as a rule entirely unsatisfactory. A particularly poor but common type of hood was one placed over three or four brushes without connection with the blower system (sketch A). Another type of hood, somewhat less inefficient, was one made in such a way as not to extend far

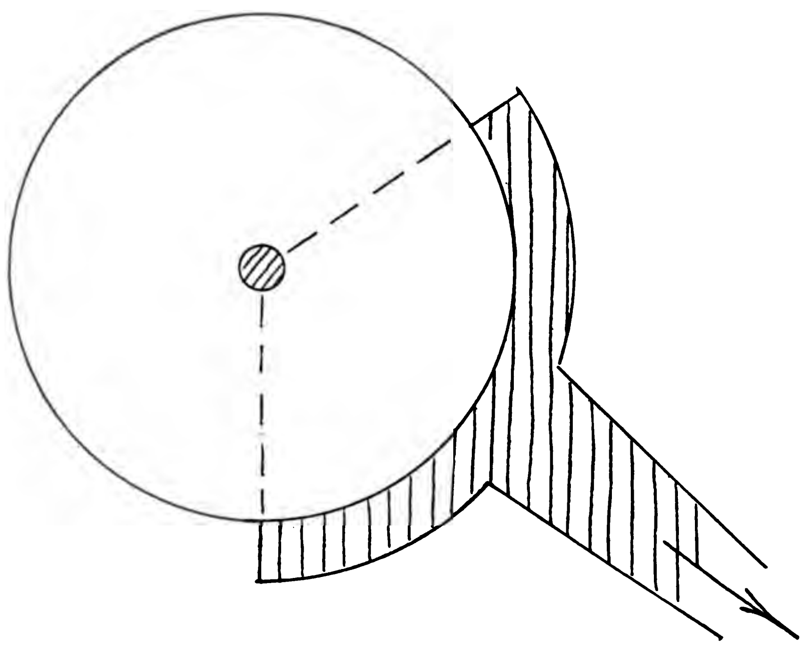
enough over the top of the wheel (sketch B). In other instances machines were improperly protected because of obviously inefficient hoods (sketch C). With an efficient hood, ¼ to ½ inch pressure in the exhaust pipe would be sufficient. In the case of an obviously inefficient hood the pressure was increased in one instance 3½ inches. This is a waste of power without results, since the type of hood in question could never be made efficient, however much the pressure was increased. This instance also illustrates the manner in which the problem is sometimes handled by the management. If a system is not efficient it is generally assumed that the draft



SKETCH B.

is at fault, and the blower is run at a greater speed, or a larger blower is installed at considerable expense, with little if any good result. If, however, more attention were paid to the hoods, better results could be obtained at moderate expense. One type of hood devised for the bottom finishing brushes extended well over the wheel, between 30 and 40 degrees beyond the perpendicular (sketch D). Such an extension of the hood did not interfere in the least with the work. Owing to the fine, light character of the dust, and the great peripheral speed of the large brush, often between one-half and one mile per minute, centrifugal force carries much of the dust around on the brush and throws it in the operative's face. In this connection should be mentioned the fact that the bristle brushes wear

away so that a 16-inch brush wears down sometimes to 8 inches before it is discarded. Inasmuch as the diameter of the wheel, and therefore the peripheral speed, is changing, the hood must be made to conform to new conditions. This is done by providing a vertical, galvanized iron plate, sliding in a slot in the upper part of the hood and adjusted by a thumb screw. This plate, which is slightly wider than the brush, may be adjusted from time to time so that it just clears the brush and thus keeps back the dust that was carried around the wheel by centrifugal force. Experiments with this type of hood have been entirely satisfactory. This exception

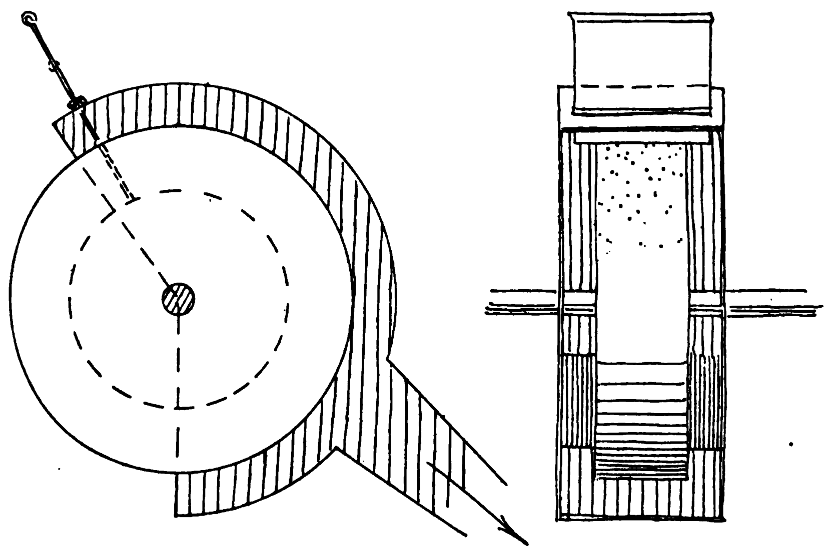


Sketch C.

to the rule that hoods should not be adjustable was the only one found. All these machines should be connected with the blower system.

The problem of dust removal from the xpedite machine is an entirely different one. The posture of the operative has already been described. The dust from the machine is fine, moist and sticky. It is not readily distributed and it tends to stick where it first lands. When handled it is soft and readily molded into a sticky ball. The brush is of small diameter, 6 or 7 inches, and run at slow speed, making about 800 revolutions per minute, therefore of low peripheral speed, which diminishes materially the amount of dust carried around the brush by centrifugal force. When one compares the brush with the bottom finishing brush a striking difference is

noted. The bristles of the bottom finishing brushes are dry, firm and resilient, so that when sprung down they fly back into position, a fact which enables them to throw more dust as the shoe is pressed against the brush or moved about upon its surface. The bristles upon the xpedite brush, on the other hand, are fine, matted like trampled grass, and sticky, because the operative uses more pressure and the dust is moist, so that less dust is carried around the brush by centrifugal force. Dust records demonstrated that there was considerable undue exposure to dust from this machine because of improper hooding and, as was previously stated, by the removal of hoods by the operative. In a few cases the machines were



SKETCH D.

connected with the blower system, and it was noted that at the same time more efficient hoods were provided, so that the diminution of the amount of dust was due rather to the increased efficiency of the hood than to the addition of the blower system. This fact may clearly be shown by comparing dust records, taken from machines adequately hooded alone, with those taken from machines adequately hooded and attached to the exhaust system. The fact may also be shown by comparing the dust records taken before and after the draft is cut off on machines adequately hooded. The xpedite machine gives us a good example of the importance of the hood, and demonstrates the fact, which may be applicable to other processes or industries, that an operative working upon a low-speed brush of small diameter giving rise to dust of this type may be adequately protected by an efficient hood with a trap below to catch the dust and dirt, without the

necessity of connecting the hood with an exhaust system. This fact seems to be of considerable importance, inasmuch as a blower system is the most expensive necessity that a manufacturer has to provide for his operatives. The hood, in the case of the xpedite machine, should extend well over the wheel, between 30 and 40 degrees beyond the perpendicular. A hood of the type devised for bottom finishing may be used upon this machine. Operatives may say that the hood cannot extend over the wheel beyond the perpendicular without interfering with the work, but such a statement is not true, and the operatives who make the statement are in the minority. In fact, one man was seen doing rapid, efficient work with a hood extending over his brush 40 degrees beyond the perpendicular. He thus had ample dust protection without a blower system.

Exhaust System for the Removal of Dust generated in the Course of Manufacturing Processes.

Given a machine equipped with an efficient hood, the question arises whether it is always necessary that the hood be connected with a system of pipes and an efficient draught for the removal of dust. In other words, if employees are exposed to an undue amount of dust generated in the course of a manufacturing process, the question arises whether it is the hood that is at fault or the blower and pipe system, or both, and why. Given an exhaust system in an establishment, the following method is used to measure the pressure, that is, to determine the draft each machine connected with the system is receiving. The instruments needed are a small "prick punch," a hammer and a U tube, one arm of which is connected with a piece of rubber tubing about 6 inches in length. A small hole is made in the exhaust pipe in the first section of the pipe behind the hood. The U tube is half filled with water, and the tube held in an upright position, so that the water will be at the same level in each arm. The end of the rubber tube is placed over the hole in the pipe made by the "prick punch," the difference in level of the water in the arms of the tube noted and measured and the pressure recorded. The caliber of the tube makes no difference so long as it is the same in both arms. The practice of making holes in the pipes is unobjectionable, as the holes are small and are soon filled with dust. In order that the records may readily be taken without breaking tubes, the U tube may be placed in a groove of similar shape on a piece of soft pine board and a scale marked between the arms. Applied to the shoe industry, the following table gives the pressure for the different types of dust-producing machines when they are properly hooded, while pressures lower than the figures stated will, as a rule, be the cause of an inefficient dust-removal system, and any increase in pressure will be a waste of power: —

Machine.	Pressure in Inches.
Edge trimmer,	1–1½
Heel shaver,	1–1½
Heel seat trimmer,	1–1½
Heel scourer,	1–1½
Breast scourer,	1–1½
Bottom scourer,	2–2¼
Naumkeag,	2–2¼
Bottom finishing brushes,	¼– ½

When pressure records show that the pressure is at fault, it is necessary to find out what conditions cause the fault in pressure. One of the most common conditions is an overloaded exhaust system, due to the fact that machines have been added from time to time to the original exhaust. Such a practice finally breaks the rule that "the sum of the area of the branch pipes must not be greater than the area of the main pipe." If this happens, every machine in the "battery," and not only the last machine added, will be inefficiently equipped. The amount of the inefficiency, however, will not be equal, but will increase steadily along the line, from the machine next to the blower to the last one of the line. This fact can be clearly shown both by pressure and dust records, each acting as a check upon the other. Then, too, it is necessary to note the manner in which the system is laid out; too acute or too many angles in the branch pipes will cause an enormous waste of power, due to friction, as will also the use of pipes of too small diameter. For example, in one factory 5 angles, 4 of which were unnecessary, were made in one branch pipe. It was found that the small pipes were readily clogged. Observations of this type were numerous. Pipes in many instances had been laid out by "rule of thumb" by some local plumber, or altered and repaired from time to time by some one unskilled in this line of work. Thus, in factories having the most up-to-date shoe machinery, hoods long obsolete were frequently noted, as well as blower systems constructed in violation of most of the laws of mechanics and of common sense.

The upkeep of an exhaust system will often give a clue to loss of power, as in cracked pipes, leaking joints, or a main pipe, the bottom of which has a deposit of dust, a fact, of course, which materially diminishes the diameter of the pipe and also causes waste of power by increased friction. In order to find out the condition of the main pipe if "traps" are present, the "traps" may be opened and the arm inserted for investigation. In some of the

smaller systems where there are no "traps" the "cap" at the end of the main pipe may be removed and examination made at this point. If the system is properly laid out and is in a good state of repair and we still find a lack of draught it is well to look at the fan or blower to see that it is of proper size and run at sufficient speed. Some systems may be made efficient by increasing the speed of the blower, but this can only be done to a certain extent. Assuming a blower of suitable size, run at sufficient speed, with a properly constructed system, even then the system may be inefficient because of an overworked or improperly constructed dust separator outside the factory and because of too long an outside "carry" to the separator. These conditions were met both singly and together.

This brings us to the community blower system. By a community blower system is meant a system so connected with a number of factories that dust generated in the course of manufacturing processes is conveyed into a common dust separator.

The overworked separator gives rise to a state of conditions analogous to the overworked blower system in a single factory. Here, one factory after another is added until the dust of all the factories may be inadequately removed. This condition of a long "carry" and an overworked separator was noticed in certain Lynn factories.

Bends and turns in the pipe, even of long radii, will cause considerable drop in pressure, whereas in the straight pipe the friction of the moving air is a source of considerable loss. The friction increases with the length of the pipe, and inversely as the diameter. It also varies as the square of the velocity. In long runs of pipe the increased cost of the larger pipe can often be compensated by decreased cost of the motor and power for operating the blower. Formulæ for loss by friction are unsatisfactory because a determination of the friction of air flowing through a pipe involves at least all the following factors: units of time, volume of air, pressure of air, diameter of pipe, length of pipe, and the difference of pressure at the ends of the pipe or head required to maintain the flow. None of these factors can be allowed its independent and absolute value, but is subject to modification in deference to its associates. Measurements of velocity of air in pipes by an anemometer should be used with great caution, for the percentage of area is not constant but varies with the diameter of the pipe and the velocity of the air. It is evident that the estimation of the loss by friction is a separate problem in each factory, and that in its computation many sources of error enter. We can, however, avoid or reduce to a minimum the various conditions which may increase it.

This brings us to the consideration of the size of pipes. The following table gives the diameter of the branch pipes used on the various machines whereby friction is reduced to a minimum: —

Machine.	Diameter in Inches.
Edge trimmer,	4
Heel shaver,	4
Heel seat trimmer,	4
Heel scourer,	5
Breast scourer,	3
Bottom scourer,	6
Naumkeag,	5
Bottom finishing brushes,	4

To estimate the size of the main pipe required and the size of the blower it is necessary to determine the total area under consideration, that is, the sum of the areas of all the branch pipes. It is then necessary to provide a main pipe of such diameter that the area will be greater than the sum of the areas of the branch pipes. The following table shows the area that blowers of various diameters can care for when worked at full load: —

Diameter of Fan in Inches.	Area (Sum of Area of Branch Pipes in Square Inches).
30,	100
35,	150
40,	200
45,	250
50,	300
55,	375
60,	450
70,	600
80,	800
90,	1000

The figures given in this table allow for 25 per cent. increase; that is, when forced the fans will care for areas 25 per cent. greater than given in this table. To illustrate; if we have the following combination of machines upon one blower and wish to determine if the blower is of sufficient size, it can be done in the following manner: first find the area of each pipe by the formula, area equals πR^2, equals 3.1416 x the square of the radius of the pipe, then add all the areas together, and by referring to the table the diameter of the fan can be easily determined.

Machine.	Inch Pipe.
6 Edge trimmers,	4
1 Heel shaver,	4
2 Heel scourers,	5
1 Breast scourer,	3
2 Bottom scourers,	6
1 Naumkeag,	5
2 Bottom finishing brushes,	4

Machine.	Area of Pipes in Square Inches.
6 Edge trimmers (2 x 2 x 3.1416), equals	74.4
1 Heel shaver (2 x 2 x 3.1416), equals	12.4
2 Heel scourers (2.5 x 2.5 x 3.1416), equals	42.5
1 Breast scourer (1.5 x 1.5 x 3.1416), equals	7.0
2 Bottom scourers (3 x 3 x 3.1416), equals	56.5
1 Naumkeag (2.5 x 2.5 x 3.1416), equals	21.3
2 Bottom brushes (2 x 2 x 3.1416), equals	24.8
Total area of branch pipes,	238.9

Referring to the table it will be seen that a 45-inch fan will care for an area of 250 square inches, and would be suitable in this case. The area of the main pipe must be greater than the sum of the areas of the branch pipes because of increased friction in small pipes, and allowance must be made for the length of the "inside carry." The speed varies inversely with the circumference of the blower, that is, the smaller the blower the faster it must be run. The horsepower varies with the cube of the speed. Both these factors, however, depend upon the length of "carry," that is, the distance from the blower to the most distant machine, — which should not be more than 125 feet, — as well as the size of the main pipe, the number of branches, the angles of branches, the nature of the work, etc. For this reason the speed cannot be figured theoretically with any degree of accuracy. Having determined the size of blower necessary for a given area of pipes the blower must be run at such speed as will give the required pressure by the U tube test. There must not, on the other hand, be too long a "carry" to the dust separator, which, in turn, must not be overworked. The "carry" outside the factory, that is, from blower to separator, is not so important as the distance from the blower to the main pipe, where there is the loss in

pressure due to pipe branches. While the inside "carry" should not be over 125 feet, some authorities estimate that with an efficient separator for an efficient system the outside "carry" could be as great as 1,500 feet. As a matter of fact this distance is rare. The largest outside "carry" noted was 800 feet, while in many instances the distance was not more than from 200 to 300 feet.

It was observed that dust removal was much more satisfactory in the factories in Brockton, Braintree and Stoughton than in those in Lynn. One apparent reason for this was the fact that the community blower system, where several factories pipe their dust into an overworked dust separator, was common in Lynn but was not in use in the other three towns.

Some manufacturing establishments, particularly those of recent construction, are provided with model dust-removal systems.

The accompanying specimens of the dust-producing units of certain machines in different factories give an accurate idea of the nature and amount of dust to which operatives are exposed. The dust records obtained show the amount of dust arising from the various processes under varying conditions. Several hundred of these records were made, many of which are on file for future assistance in the enforcement of the laws relating to the efficiency of dust-removal devices and the protection of employees against dust.

An examination of the records makes clear the fact that the dust-producing units of the processes under consideration should all be hooded and connected with an exhaust system, with the exception of the xpedite machine, which, it would appear, may be amply protected by hood alone. Following are tables showing (1) the number of revolutions per minute made by the different dust-producing units; (2) the diameter in inches of these units; (3) the number of feet per minute, showing their peripheral speed; and (4) table for equalizing the diameter of pipes.

Machine.	Number of Revolutions per Minute.
Edge trimmer,	7,200–11,000
Heel shaver,	5,000– 6,600
Heel seat trimmer,	5,500– 6,600
Heel scourer,	4,000– 5,500
Breast scourer,	1,800– 2,400
Bottom scourer,	1,800– 2,700
Naumkeag,	3,500– 4,000
Bottom finishing brush,	600– 1,600
Xpedite,	750– 900
Upper cleaner,	600– 1,000

Diameters of Dust-producing Units.

Machine.	Diameter in Inches.
Edge trimmer: —	
(*a*) Fore part cutter,	$1\frac{3}{8}$–$1\frac{5}{8}$
(*b*) Shank cutter,	1 –$1\frac{1}{8}$
Heel shaver,	3
Heel seat trimmer,	3
Heel scourer,	6
Breast scourer,	$3\frac{1}{2}$
Bottom scourer,	4
Bottom finishing brushes,	8 –16
Xpedite: —	
(*a*) Canvas roll,	6
(*b*) Bristle brush,	6 – 7
Upper cleaner,	8 –12

Table of Peripheral Speed.

Machine.	Feet per Minute.
Edge trimmer: —	
(*a*) Fore part cutter,	2,580–4,798
(*b*) Shank cutter,	1,884–3,252
Heel shaver,	4,362–5,236
Heel seat trimmer,	4,362–5,236
Heel scourer,	2,826–4,239
Breast scourer,	1,648–2,198
Bottom scourer,	4,182–5,752
Bottom finishing brushes,	2,508–5,016
Xpedite: —	
(*a*) Canvas roll,	1,177–1,496
(*b*) Bristle brush,	1,177–1,646
Upper cleaner,	1,256–3,141

Given a practical method for determining and recording the amount and character of dust to which an operative is exposed, the next step necessary in order to insure a correct interpretation of a dust record was to make a detailed study of the construction and arrangement of the hoods and exhaust systems under all sorts of conditions.

For example, a record is taken showing that an operative is exposed t considerable amount of dust, such as brass or emery. Before concludi that the process is dangerous (and one from which minors should be cluded) it may be found that the exposure to dust was due to the lack or to an ineffective, system of protection rather than to the process its as shown by records taken from similar processes under different conditio

The most important factors under consideration were the general layo of the system, diameter of pipes, angles of branch pipes, size of fans a speed at which they were run, and air pressure in the main and bran

TABLE FOR EQUALIZING THE DIAMETER OF PIPES.

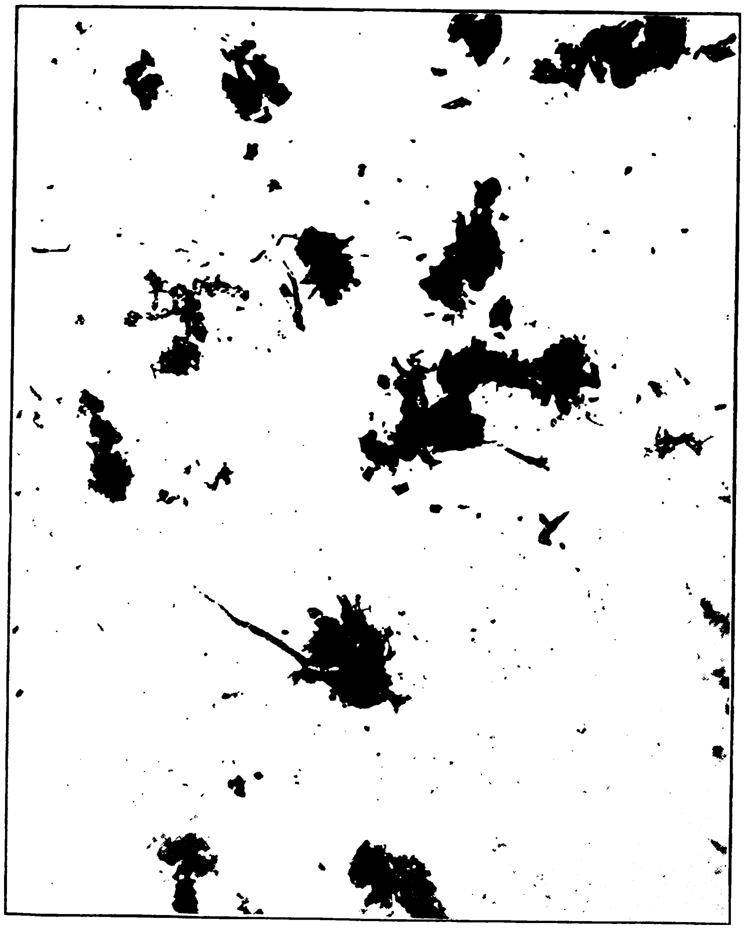
This table is based on the laws of friction of gases in pipes, and gives the number of different sizes of smaller pipe, equal to one large pipe. Choose from the left hand column the size of main pipe, then the head of each vertical column gives the size and the horizontal line under that head the number of such pipes equal to main pipe.

1	1																												
2	5.7	2																											
3	16	2.7	3																										
4	32	5.7	2.	4																									
5	56	9.8	3.6	1.8	5																								
6	88	16	5.7	2.8	1.6	6																							
7	129	23	8.5	4.1	2.3	1.5	7																						
8	180	32	12	5.7	3.2	2.1	1.4	8																					
9	244	42	16	7.6	4.5	2.8	1.9	1.3	9																				
10	317	56	20	9.9	5.7	3.6	2.4	1.7	1.3	10																			
11	402	71	26	12	7.0	4.5	3.1	2.2	1.7	1.3	11																		
12	501	88	32	16	9.0	5.7	3.8	2.8	2.0	1.6	1.2	12																	
13	613	107	39	19	11	6.9	4.7	3.4	2.5	1.9	1.5	1.2	13																
14	737	129	47	23	13	8.3	5.7	4.1	3.0	2.3	1.8	1.5	1.2	14															
15	876	152	56	27	16	9.2	6.7	4.8	3.6	2.8	2.2	1.8	1.4	1.2	15														
16	1026	180	65	32	18	11	7.9	5.7	4.2	3.2	2.6	2.1	1.7	1.4	1.2	16													
17	1197	208	76	37	21	13	9.2	6.6	4.9	3.8	2.9	2.4	2.0	1.6	1.4	1.2	17												
18	1375	239	88	43	24	16	10	7.7	5.7	4.3	3.4	2.8	2.3	1.9	1.6	1.3	1.2	18											
19	1580	275	100	49	28	18	12	8.8	6.5	5.	3.9	3.2	2.6	2.2	1.8	1.5	1.3	1.2	19										
20	1797	313	114	56	32	20	14	9.9	7.4	5.7	4.5	3.6	2.9	2.5	2.1	1.7	1.5	1.3	1.1	20									
22	2284	398	145	71	41	26	18	13	9.5	7.2	5.7	4.5	3.7	3.1	2.6	2.2	1.9	1.7	1.4	1.3	22								
24	2634	493	180	88	50	32	22	16	12	8.9	7.6	5.7	4.6	3.6	3.2	2.9	2.4	2.1	1.8	1.6	1.2	24							
26	3474	605	219	108	62	39	27	19	14	11	8.6	6.9	5.7	4.7	4.0	3.4	2.9	2.5	2.2	1.9	1.5	1.2	26						
28	4165	725	265	129	74	48	32	23	17	13	10	8.3	6.8	5.7	4.8	4.1	3.5	3.0	2.6	2.3	1.8	1.5	1.2	28					
30	4963	864	315	154	88	56	38	28	20	16	12	9.9	8.0	6.7	5.7	4.7	4.1	3.6	3.0	2.6	2.2	1.7	1.4	1.2	30				
36	7818	1361	497	243	139	88	60	43	32	25	19	16	13	11	8.9	7.6	6.5	5.7	5.0	4.3	3.4	2.7	2.2	1.9	1.6	36			
42	11488	2000	730	358	205	129	88	63	47	36	29	23	19	16	13	11	9.6	8.5	7.3	6.4	5.0	4.1	3.3	2.8	2.3	1.5	42		
48	13989	2782	1081	492	282	180	123	88	66	50	39	32	26	22	18	16	13	12	10	8.9	7.0	5.7	4.7	3.8	3.2	2.1	1.4	48	
54	21560	3753	1368	671	384	244	166	119	88	68	53	43	35	29	24	21	18	16	15	12	9.4	7.6	6.2	5.2	4.3	2.8	1.9	1.5	54
60	27915	4878	1781	872	499	314	215	154	115	88	69	56	46	38	32	27	23	20	18	16	12	9.9	8.1	6.7	5.7	3.6	2.4	1.8	1.8

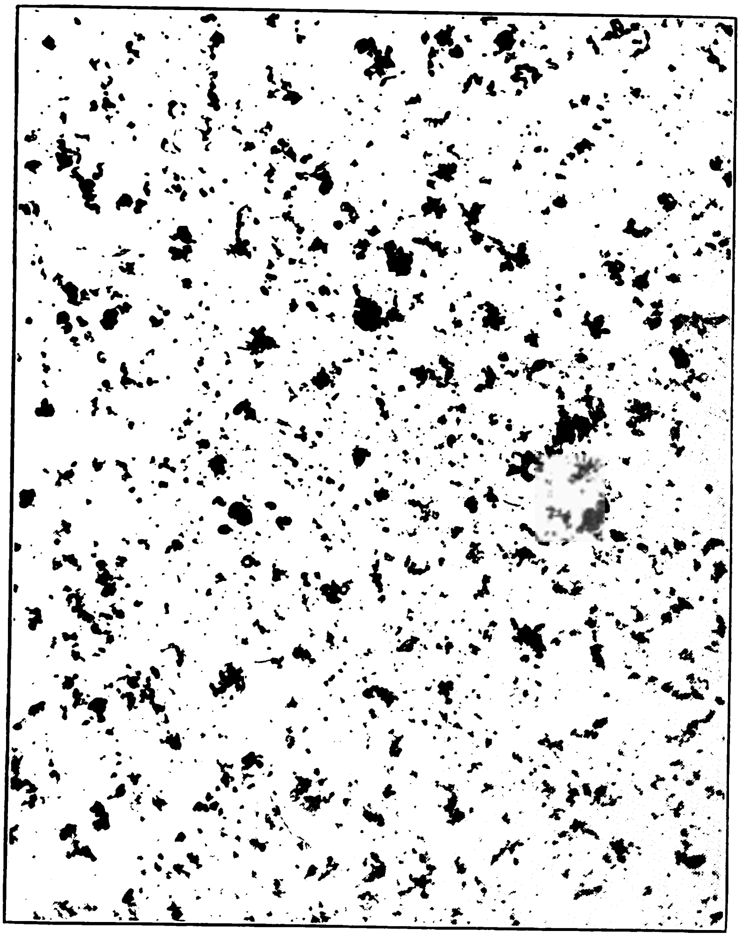
pipes, — all of which are absolutely necessary in order to avoid the dan of drawing conclusions from insufficient data.

In short, this paper demonstrates a practical method for the determi tion of the amount and character of dust to which an operative in a giv occupation or process is exposed, and points out the necessary observati to be taken before one is in a position to draw conclusions from the d at hand.

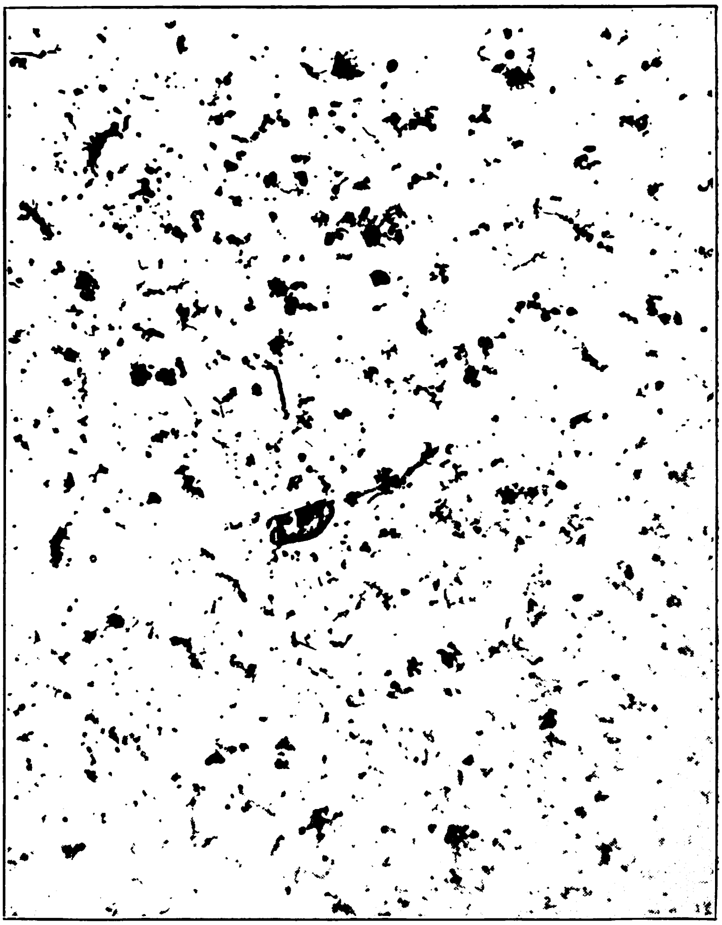
While the results obtained from the dusty processes of the shoe indus are here alone discussed, the practicability of the method has been dem strated in all the important dusty trades and dusty processes in Mas chusetts.



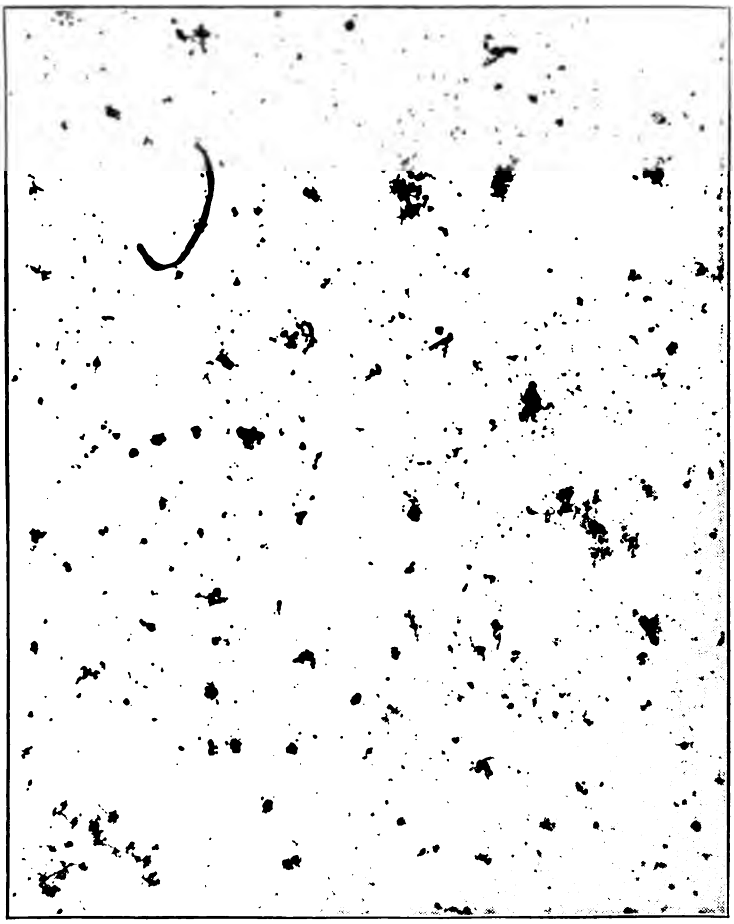
Dust from edge-trimming machine. Enlarged 40 diameters.



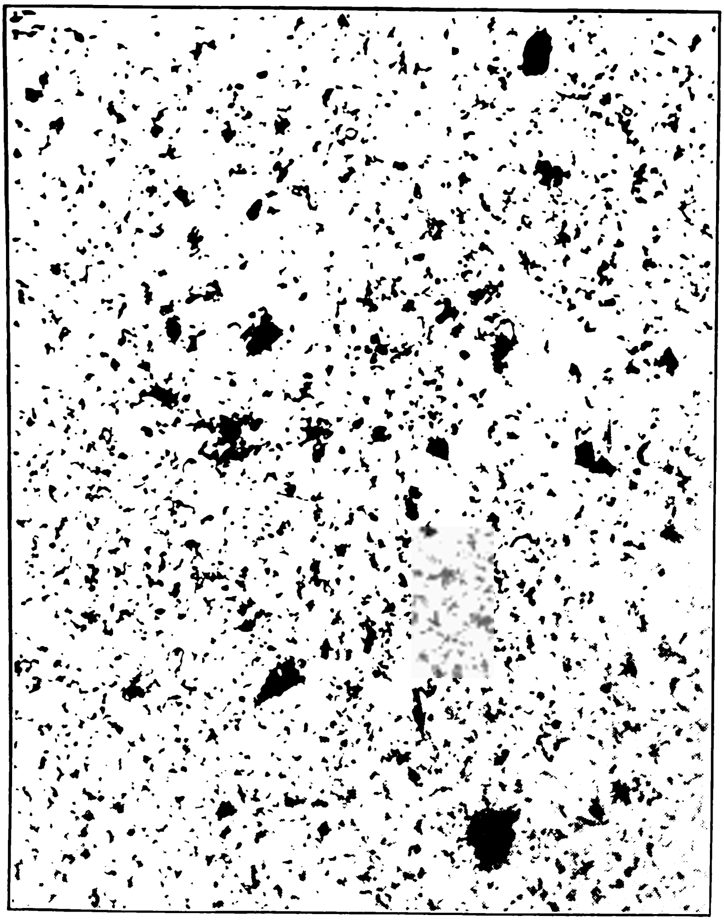
Dust from heel-scouring machine. Enlarged 40 diameters.



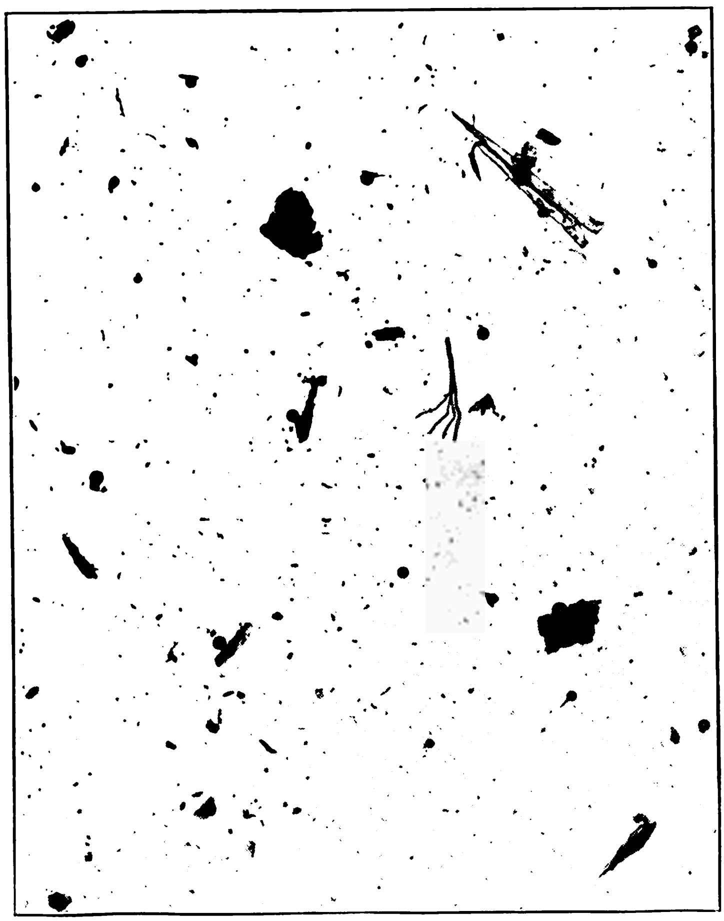
Dust from breast-scouring machine. Enlarged 40 diameters.



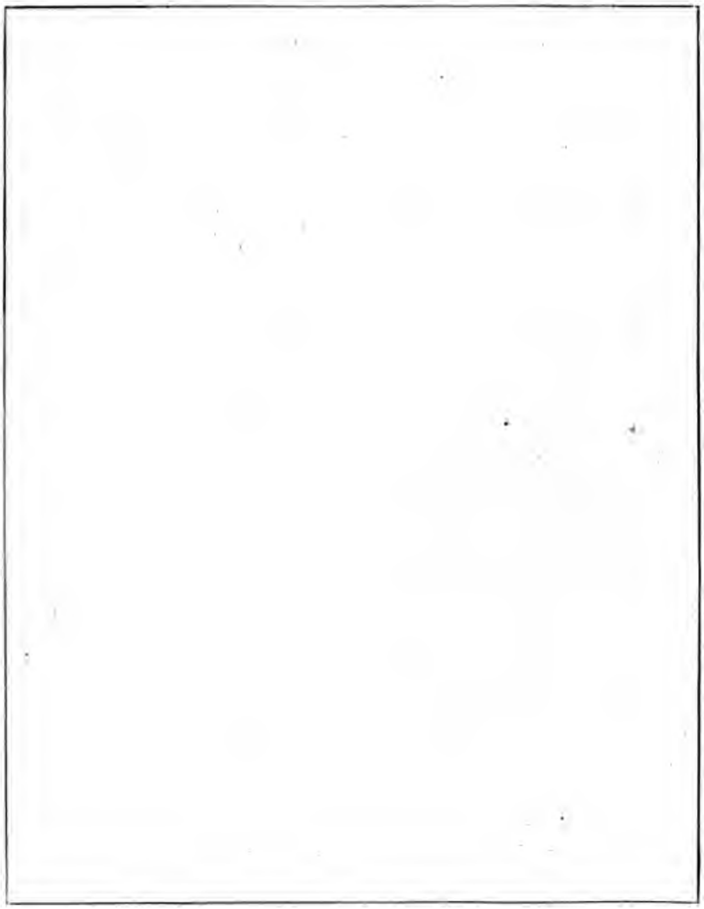
Dust from bottom-scouring machine. Enlarged 40 diameters.



Dust from Naumkeaging machine. Enlarged 40 diameters.



Dust from bottom-finishing machine. Enlarged 40 diameters.



Dust from the xpedite machine. Enlarged 40 diameters.

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